A PRELIMINARY SURVEY OF MAIZE IN THE SOUTHWESTERN UNITED STATES[1]

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Maize is uniquely variable; differences from plant to plant, from variety to variety, and from region to region are even greater than in other cultivated plants. Previous papers by Anderson and his collaborators (Anderson and Blanchard, '42; Anderson and Cutler, '42; Kelly and Anderson, '43; Anderson, '43a, b, '44a, b) have discussed the means of cataloguing this variation most effectively. They have recorded it in detail, character by character, and have described a few of the races and sub-races which are already apparent in our collections. The following paper is an attempt to classify the maize of the southwestern United States, particularly the varieties grown by the Indians. While it is more comprehensive than any previous attempt, we consider this a preliminary report since it raises many more questions than it answers, and of these, many should yield to further investigation.

Maize is also unique for purely technical reasons in its excellence for both cytogenetic and archaeological investigation. For cytogenetics it has the initial advantages of many readily available unit characters such as starchy vs. sweet kernels; green leaves vs. purple leaves. For cytological analysis it has the advantage of long, well-differentiated chromosomes. To these original advantages has been added by cooperative research a wealth of detailed technical information unparalleled for any other plant (see Rhoades and McClintock, '35). Archaeologically, maize has the advantage of its large indurated ear which resists decay and which presents almost as many significant characters for racial diagnosis as does the human skull. Therefore, when cytogenetic and archaeological informations are merged we may expect eventually a more complete, detailed, and significant history than is possible for any other cultivated plant or any domesticated animal. Such a synthesis would be useful to geneticists, archaeologists, corn breeders, geographers, ethnologists, and culture historians.

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For a number of reasons the classification of southwestern maize is a relatively simple problem; simple, that is, by comparison with modern commercial maize or the maize of Central America or of South America. Since the beginnings of its agriculture the Southwest has been semi-isolated from other agriculturally developed areas by geographical and climatic factors, and interchange with other areas has been comparatively slight. Within the region itself, maize growing has been strongly localized by climatic conditions; i. e., in contrast to Mexico or Guatemala fields were few and far apart, giving opportunity for the development of well-differentiated local varieties. Compared to most areas, the Southwest is well known ethnologically and archaeologically. Modern and prehistoric maize is already on hand in museum collections[2] in considerable quantity while in practically any other area one must first assemble his own collections. We have artificially simplified the problem even further by leaving out the question of sweet corn. It is grown by a number of southwestern tribes (most particularly by the Hopi), but as Kelly and Anderson have pointed out ('43), the origin of sweet corn is a rather different problem technically from the origin and development of dent and flour corns. The whole question of sweet corn in the Southwest is therefore postponed for further publication.

Unfortunately, collections of modern maize need to be made with extreme care if they are to be of maximum usefulness. Maize is a very sensitive mirror of the people who have been growing it. Collections made from Indians living along concrete highways or in the suburbs of modern American towns will be faithful reflections of the extent to which they have left their old ways. A progressive Papago Indian who owns a small truck and lives on the highway between Sells and Tucson will have seen various kinds of maize in the course of his work and may bring back a good many to try out in his corn field. While most of them may not be well suited to these peculiar desert conditions, if they survive even for one season, the wind may carry their pollen to other plants and a new element will have been introduced into this particular cornfield. Yet the ordinary collector will be satisfied with Papago maize from such a source and will not press on over the long dry road to Sells and then go farther still on side roads into the reservation to find Papago maize which shows no evidence of Yankee contact, none of Spanish contact, and very little contact with other Indians. Yet such maize was characteristic of Papago communities as late as 1943. To some students who have collected maize in the Southwest an Indian was an Indian, and the idea of spending an extra day or an extra week in reaching a seed source of unimpeachable significance seemed a waste of time and effort in a country where travel was difficult. Even those who understood these matters were impeded by the practical necessity of getting back to their base of supplies. The very slight literature on the maize of the southwestern Indians is therefore shot through with information which is only partly true and which would need the joint services of an agronomist and an ethnologist to interpret correctly.

[2] As, for instance, the remarkable collection assembled by Volney Jones and A. F. Whiting at the Museum of Northern Arizona (See Whiting, '39).

In so far as possible our collections were made directly from Indian fields or granaries and from Indians who by ethnological standards were representative members of their groups. The numbers of ears are small (Table II) but the collections are more significant than larger, uncritical ones. Since much of the work was done while both of the authors were traveling from place to place it was seldom possible to measure the entire collection (the bulk of which was divided between Berkeley and St. Louis). Accordingly, for most of the pueblos, the quantitative observations reported below have been confirmed by qualitative observations on a duplicate collection. More recently the junior author has had the opportunity to measure comprehensive collections of twenty-five ears each for eight different varieties. These were distributed as follows: Papago, Tesuque, San Juan, Navajo, Hopi (two varieties), Isleta (two varieties). All these collections confirm and extend the conclusions reached in this paper.

One's first impression of the maize grown in most of the pueblos is that it is extremely variable. This is due to the fact that the eye is quicker to note differences in color than in proportion. Color differences, however, are relatively superficial. In the entire Southwest not more than ten loci in the germ-plasm are responsible for the variation in cob and kernel color, while many more than that are at work in determining cob shape, kernel size, row number, etc. As explained in the first paper in this series (Anderson and Cutler, '42), such characters, though difficult to work with, are therefore superior as criteria for races and sub-races. Color differences, however, have not been ignored but were the object of a special investigation which will be published separately.

One of the characters used in our classification deserves special discussion, partly because it is so important in revealing differences and resemblances between southwestern varieties and partly because its exterior manifestations are somewhat different in the Southwest from what they are in other regions. This character is technically known as denting. In its typical form (pl. 3) it produces a mature kernel which is shrunken at the tip. It is, however, an extremely variable character, and the dent may be either rough or smooth and deep or shallow. When well developed it will affect all the kernels on the ear with the possible exception of a few at the base and the tip. Genetically, we know very little about this character except that it is complex and is apparently affected by a very large number of genes. Our collections of North American maize show that denting reached its strongest development in the region around Mexico City and radiates from there in all directions. In the Southwest it is present but in a very diluted state. Many of the ears which we have scored as dented (pl. 3) would not be referred to as dent corn in the American corn belt, but upon careful examination several of the kernels show a slight dent in the surface of the kernel. Examination of granaries and maize fields have shown us that when such ears are found, invariably sister plants occur with kernels much more strongly dented. Archaeologically, denting is important because it indicates some kind of connection with the Mexican Plateau and because it is one of the consistent differences between

Pima-Papago and Basketmaker maize. When and by what route it entered the Southwest is a matter of great archaeological importance. Collections of prehistoric maize in the Southwest should be carefully examined for any indications of dented kernels. They are illustrated, though without comment, in Nussbaum and Judd's collections from Cottonwood Cañon in southeastern Utah, and the remarkable ears collected by Scoggin in northwestern Colorado (which were submitted to us for study) are as strongly dented as Mexican varieties.

Maize in the Southwest stems from at least four different sources. (1) The race grown by the prehistoric "Basketmakers," the first agriculturists of whom we have any record in the area, was relatively uniform. It was slender-cobbed, tesselate-seeded (like tiles in a pavement, see pl. 2), compressed at the butt, and with strong husk striations. Unfortunately, not enough plant material has been saved in archaeological studies to indicate the plant type associated with this type of ear. (2) Similar (though apparently not identical) varieties are still being grown by the Pima, the Papago, the Yuma and related tribes. They too are slender-cobbed, tesselate-seeded, and striated. The plants of these modern varieties are slender-stalked and narrow-leaved and have tillers which are sub-equal to the main stalk.

The maize of the Pueblo Indians shows strong influence from at least two other strains. It would be out of place in this preliminary discussion to go into the complex problem of just where and when the modifications took place. The old types were not completely replaced, for most of the Indian maize of the Southwest has a very strong resemblance to Basketmaker corn (as will be demonstrated below). Regardless of source, the two later introductions brought in characters which are identified with two other regions. (3) Condensed tassels (Anderson, '44b), denting of the kernel, weak leaves, a strongly tapered ear, and high row number are characteristic of the maize of the Mexican plateau. (4) Present as an admixture in Pueblo corn is a complex of characters which in its most extreme form is apparently limited to Guatemala. It is, however, markedly present in the flint and flour corns of the eastern United States though absent from most of Mexico. It is characterized by strong, arching leaves, coarse stalks, a large indurated shank below the ear, and an ear whose butt end is perceptibly larger than the rest of the kernel-bearing portion. The kernels are wide, often wider than they are long, and are arranged in long, straight, regular rows, aside from the base of the cob where the rowing is usually irregular. Throughout the remainder of this paper these last two complexes will be referred to as "Mexican" and "Eastern." These names are chosen for convenience and the two complexes may have come into the region separately or together. It is even possible that the one we are calling "Mexican" may have entered from the Northern Periphery.

If we postpone the historical interpretation of these complexes and merely use them as cataloguing devices, the results are suggestive. Figure 1 shows the data on a Mexican character (denting) and an Eastern character (wide kernel) set out in the form of a scatter diagram. A similar, but by no means identical, diagram

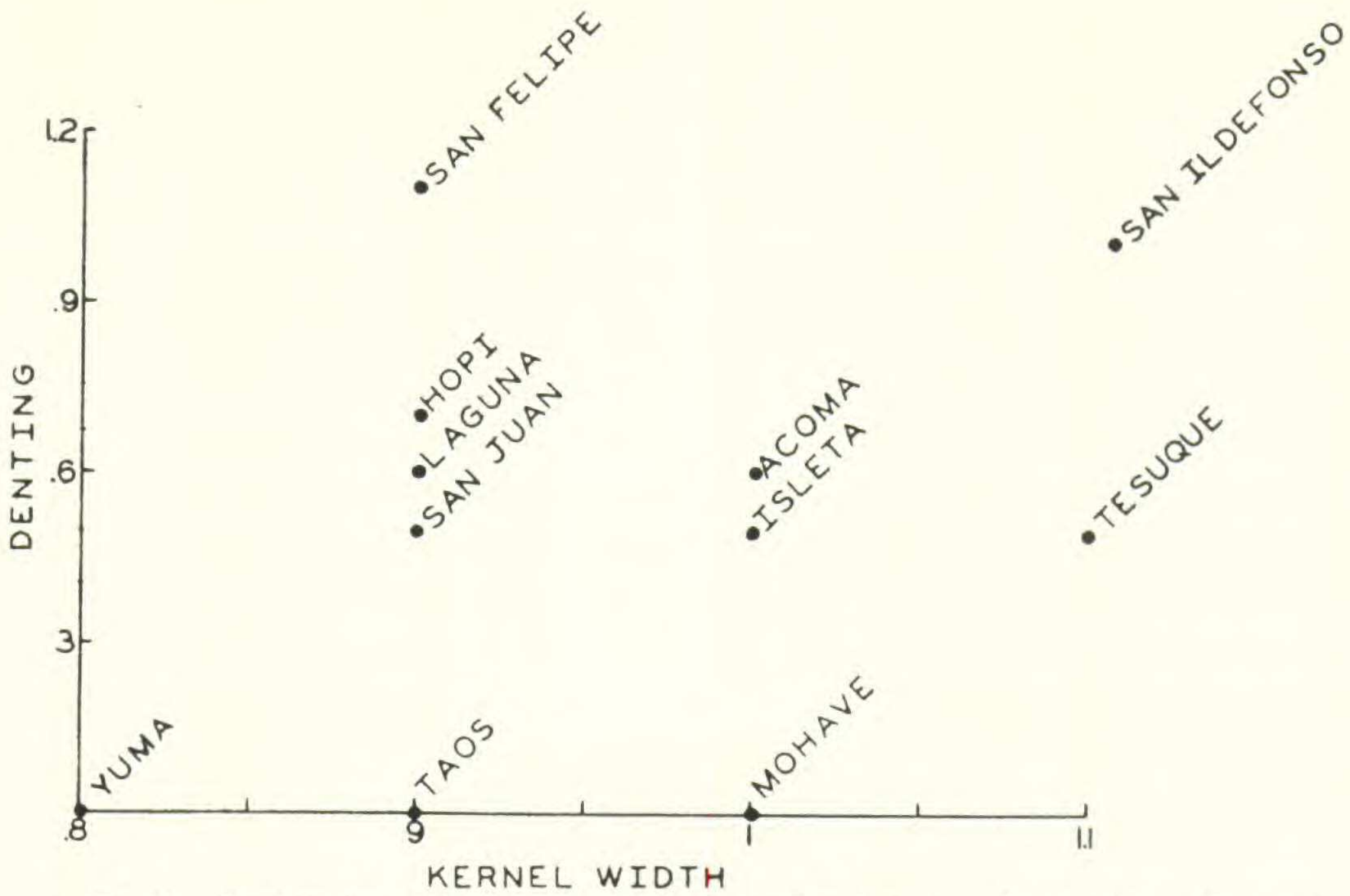


Fig. 1. Scatter diagram showing the relationship between the varieties of maize grown by various tribes in the Southwest. Each dot is an average of all the collections from the tribe.

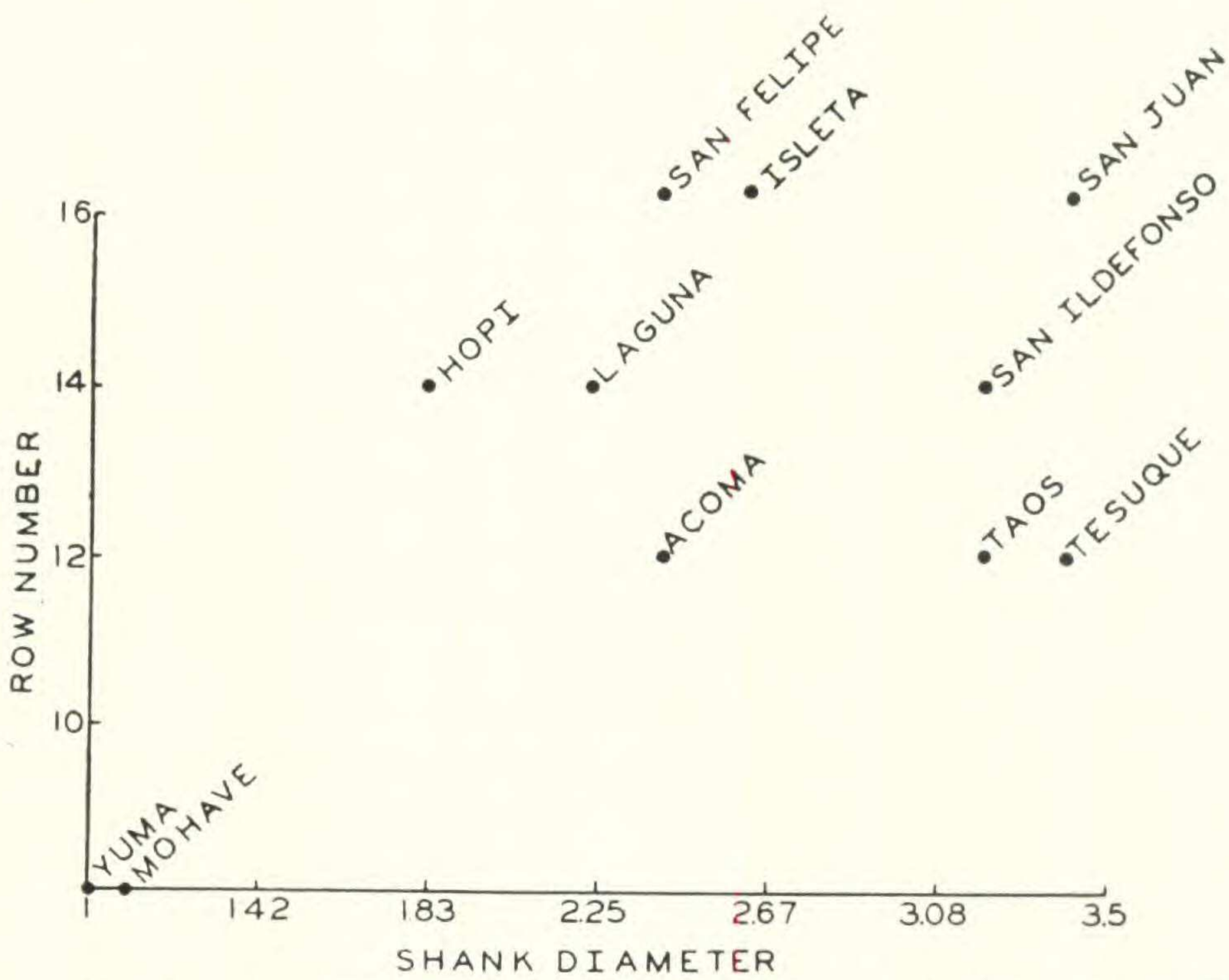


Fig. 2. The same collections as diagrammed in fig. 1, but using two different characters. In both figures a "Mexican" character has been used on the vertical axis, and an "Eastern" character on the horizontal axis.

(fig. 2) is produced if we choose two other characters, taking row number from the Mexican complex and shank diameter from the Eastern. In figs. 1 and 2 all the ears of maize from each group of Indians have been averaged and the average

values were used in making the diagrams.

The fact that figs. 1 and 2, though based on very different criteria, produce such similar diagrams of relationship, is evidence for the validity of the complexes described above. It is evidence that the combinations of characters which tend to be seen together are not wholly fortuitous and that their resemblance to races of maize in Mexico and in eastern North America probably has an historical basis. In terms of genetics it probably means that row number and denting are both multiple factor characters and that, though there has been a great deal of crossing of different types of corn in the Southwest, high row number and denting went into the mixture together (we now have archaeological evidence for this fact) and still tend to stay together on the average.

The existence of these loosely linked complexes of characters in southwestern maize allows us to extend a technique originally developed for dealing with hybrid populations (see Anderson and Turrill ('38) for details). In practice this was done step by step. When the two diagrams (figs. 1 and 2) were averaged mathematically it was found that while either one produced a fairly natural classification of the tribes and one that was in harmony with what was known about the history of their agricultural relationships, the combination of the two was superior to either alone. Row number and denting were used together as an index of the Mexican complex, and shank diameter and kernel width as an index of the "Eastern" complex. Additional characters were added to trial indices, one at a time, until at length the ten most objective and easily scored criteria were being combined in each diagram, each of the characters being given equal weight in constructing the indices.

All of the qualitative characters are put in three grades, "present", "intermediate" or "absent," which are assigned numerical values of 2, 1, and 0, respectively. Each of the quantitative characters is divided into three classes, likewise scored from 0 to 2. The actual scoring for all ten characters is as follows:

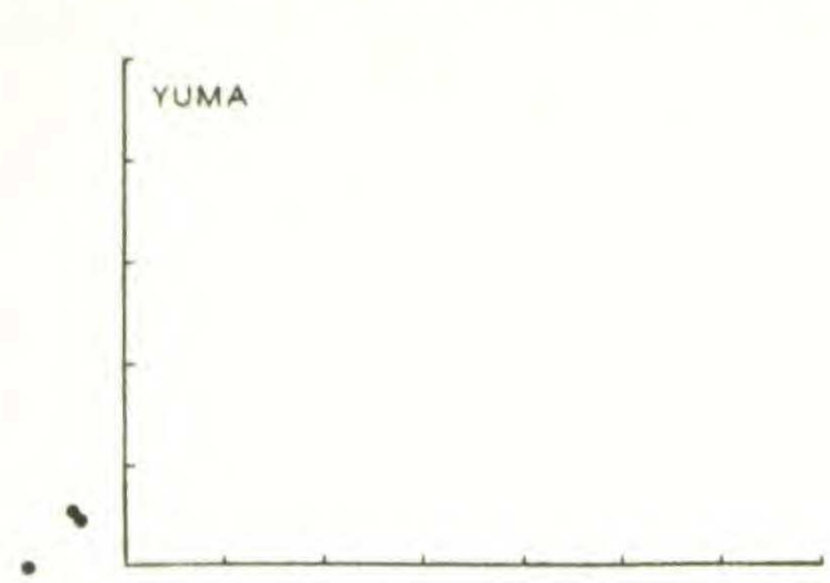
TABLE I

		0	1	2
"Mexican"	Ear taper	None	Slight	Well-marked
	High row number	8–12	14	16 or more
	Denting	None	Slight or variable	Uniform or deep
"Eastern"	Enlarged butt	None	Slight	Strongly developed
	Straight rows, uniform kernels	None	Moderate	Kernels very uniform
	Wide kernels	to .9 cm.	1.0 cm.	1.1 cm. or more
	Wide shank diameter	to .9 cm.	2.0–2.6 cm.	2.7 cm. or more
Non-Mexican Non-Eastern	Mid-ear diameter	to 4 cm.	4.1–4.3 cm.	4.4 cm. or more
	Husk striation	None	Slight or variable	Strongly developed
	Basal compression of ear	None		Strongly developed

The first three of these characters (ear taper, row number, and denting) are characteristic of the Mexican complex. They are all added and their sum is plotted on the y axis. The next four (enlarged base of ear, regular kernels, width of row, shank diameter) belong to the Eastern complex. Their sum is plotted on the x axis. We come now to a cluster of traits which do not characterize either the Mexican or Eastern complexes but which are found in both Basketmaker and Pima-Papago maize: a narrow cob, longitudinal striations across the face of the kernels, and basal compression of the ear. Depending upon the way these traits were defined and scored they might either be added to each of the indices or subtracted from each. If husk striations, for instance, were scored for their absence then the resulting score would be *added* to both the Eastern and Mexican indices. If scored for their presence then the resulting values would be subtracted for both indices. We found that for rapid scoring of large collections errors were apt to creep in if some characters were being scored in a negative and others in a positive direction. Accordingly, in taking the original data we scored all the characters positively. This complicated the mathematical treatment a little, but added to the accuracy of the data. Mid-ear width is a character by which both the Eastern and Mexican complexes differ from Basketmaker or Pima-Papago corn. Its score is accordingly divided by half and the halves are added to both the x and y axis. Husk striations on the kernel and compression of ear at the base are characteristic of Basketmaker and Pima-Papago corn and of neither the Eastern nor the Mexican complex. Their scores are accordingly added, the sum is halved and the result subtracted from both the x axis and the y axis.

All of this sounds rather complicated. In practice the calculations are really very simple. Let us take an actual instance. The ear known in our collections as CA. #240 was collected at the San Ildefonso pueblo. It is intermediately tapered, has 14 rows of kernels, and is undented. These three characters therefore contribute 1, 1, and 0, respectively to the index of the Mexican complex. The base of the ear is not perceptibly enlarged, the kernels are regular in shape and arrangement, they are 10 cm. wide, and the diameter of the shank just below the ear is 3.1 cm. By the score values as tabulated above, these four characters therefore contribute 0, 2, 1, and 2 to the Eastern Index. Adding the above individual scores gives sub-totals of 2 for the Mexican Index and 5 for the Eastern. The mid-ear width is 4.3 cm. which is in the intermediate range and therefore scores 1, giving us ½ to be added to each axis. The ear is not compressed at the base and has slight husk striations on the kernels. Its score for these two characters is therefore 1 plus 0. Dividing this by 2 gives ½, which when subtracted from both totals cancels the previous ½ and gives us total scores of Mexican 2, Eastern 5. This ear therefore appears as a dot in fig. 15, two units up from the 0 point and 5 to the right.

The scale for the Mexican complex runs from a minus 2 to a plus 7 and the scale for the Eastern from a minus 2 to a plus 8. Theoretically, an idealized Eastern ear should score: y, 0; x, 9. Several ears of Sacred Flour Corn from the


YUMA

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MOHAVE

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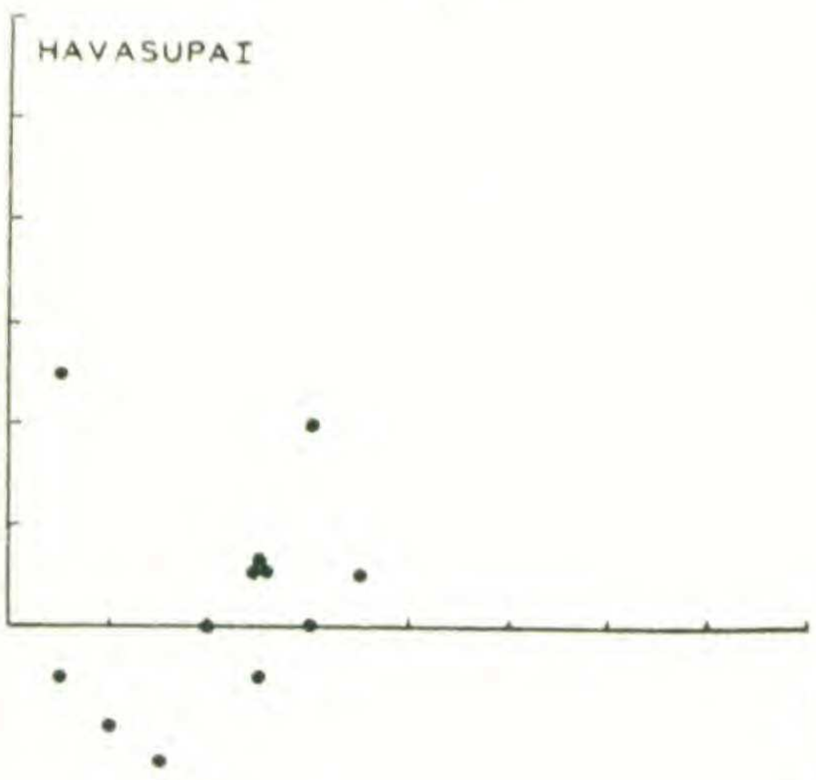
HAVASUPAI

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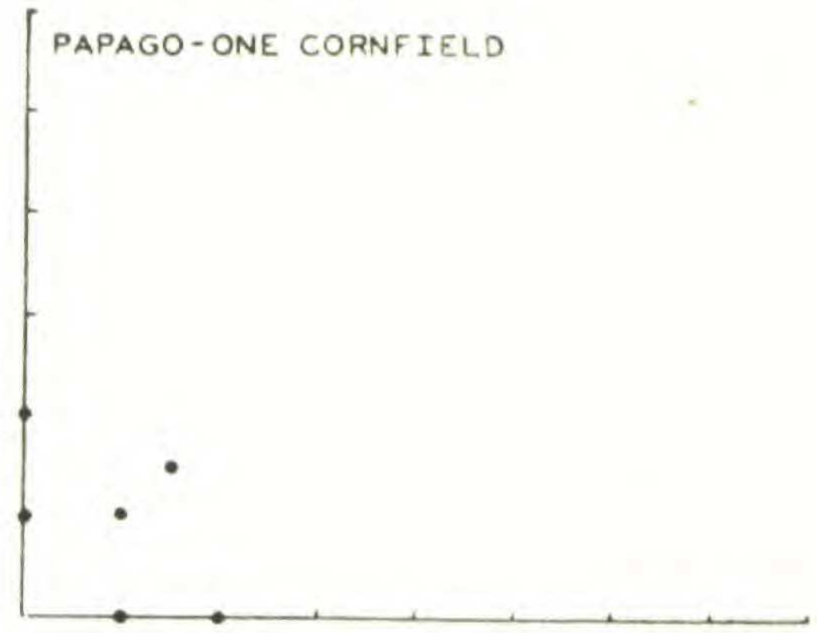
PAPAGO-ONE CORNFIELD

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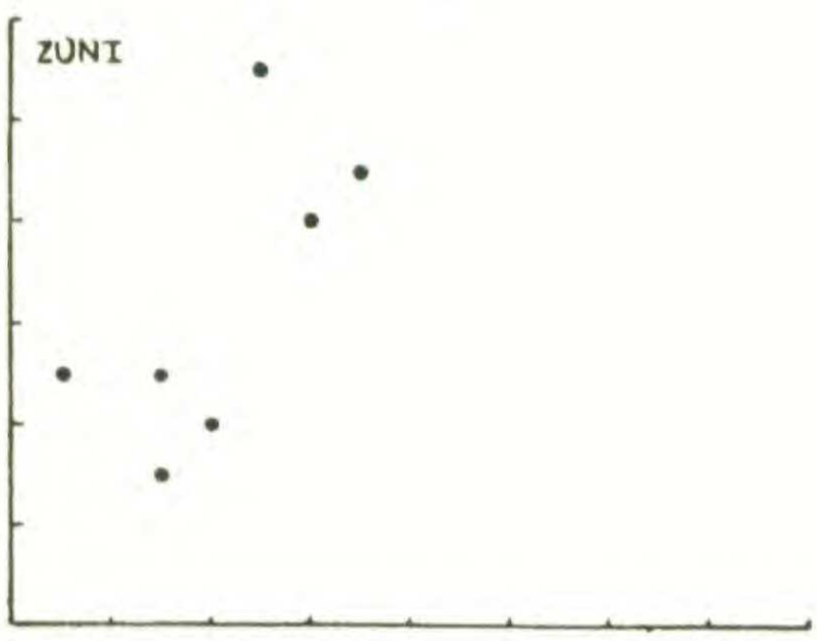
ZUNI

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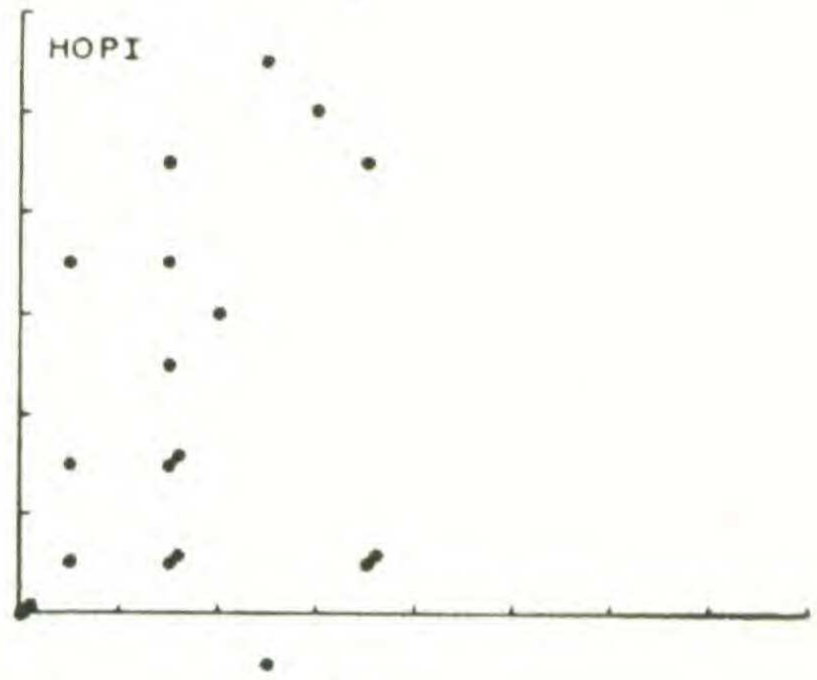
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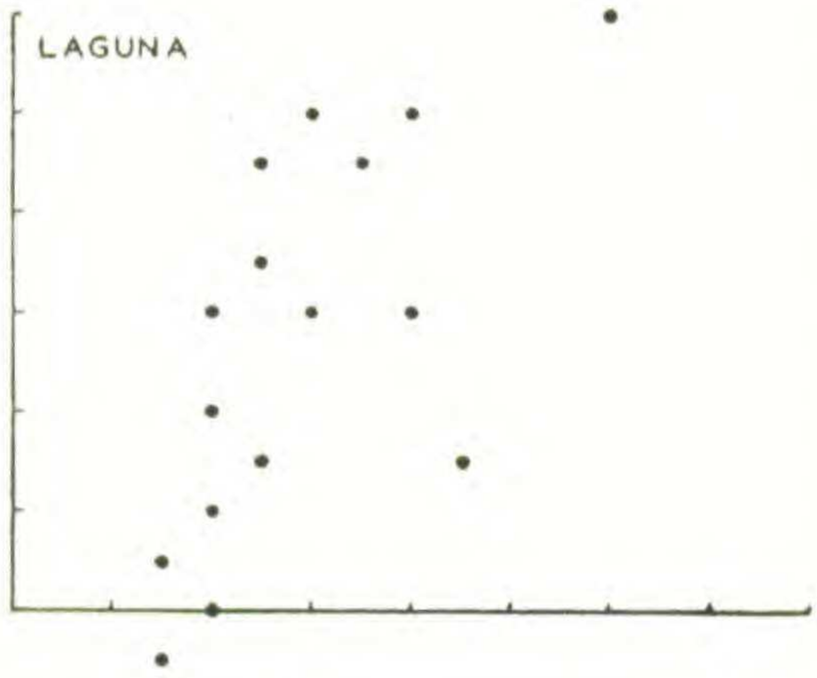
LAGUNA

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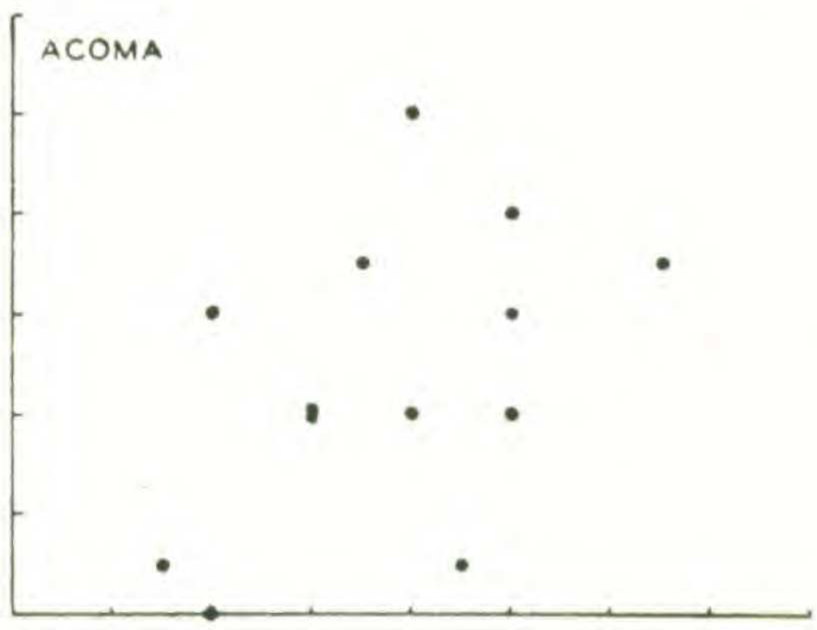
ACOMA

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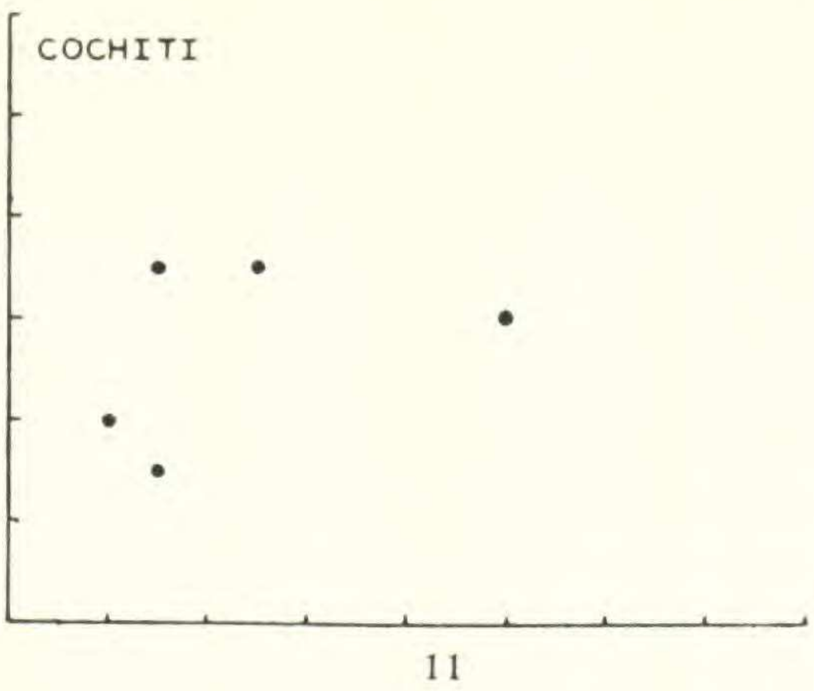

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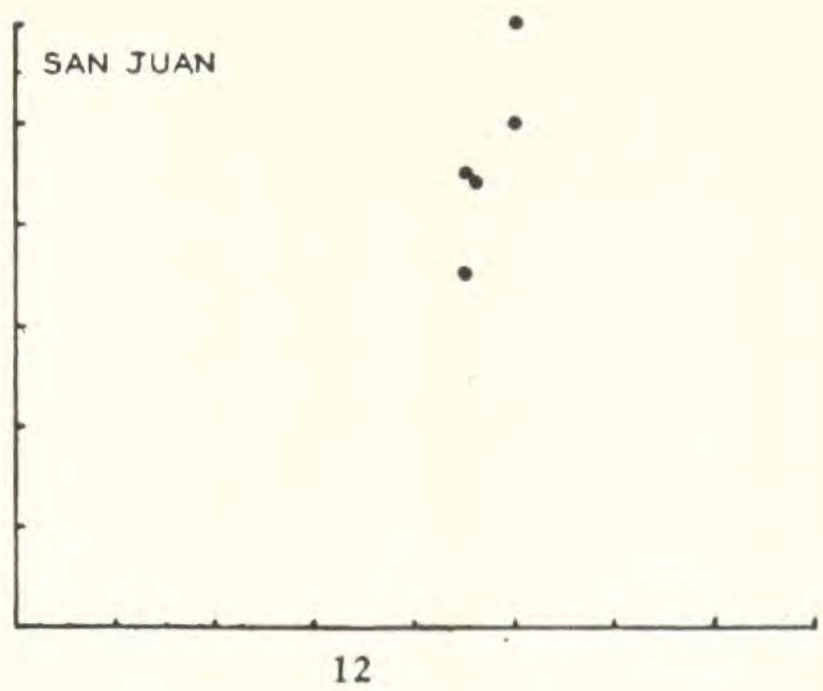

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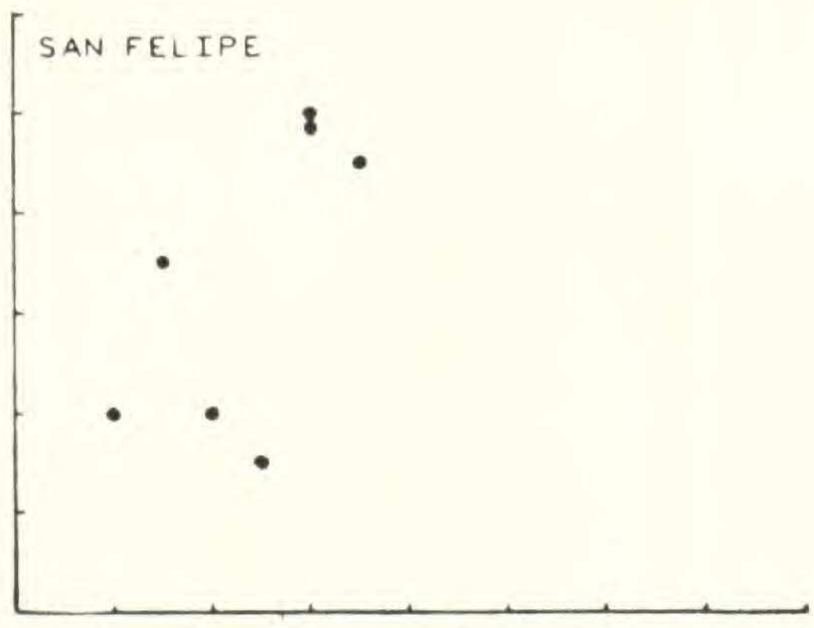

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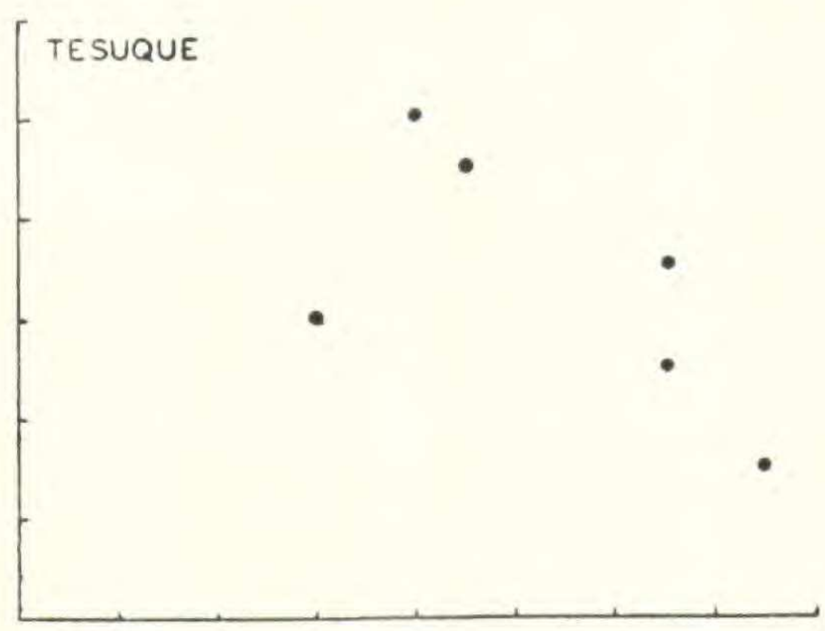

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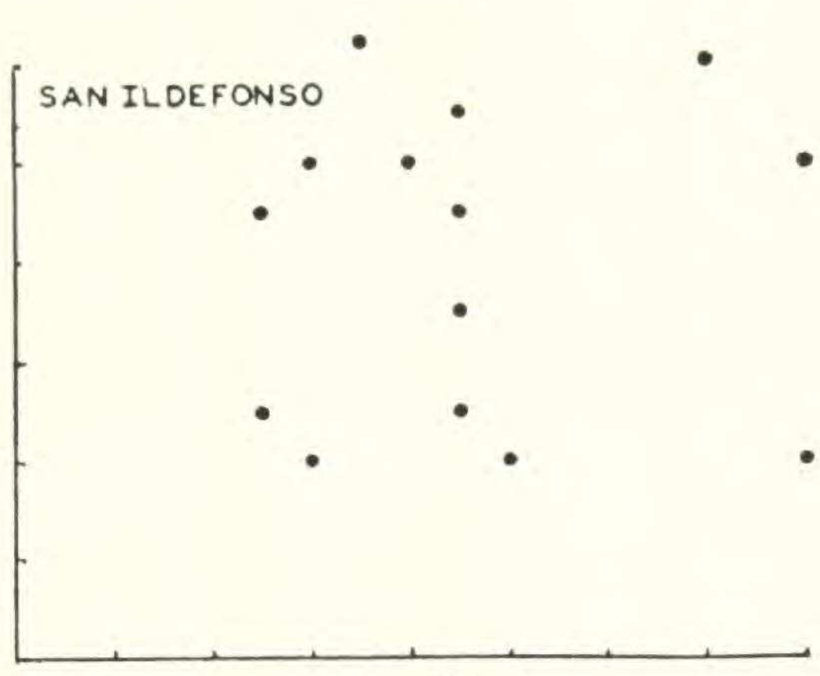

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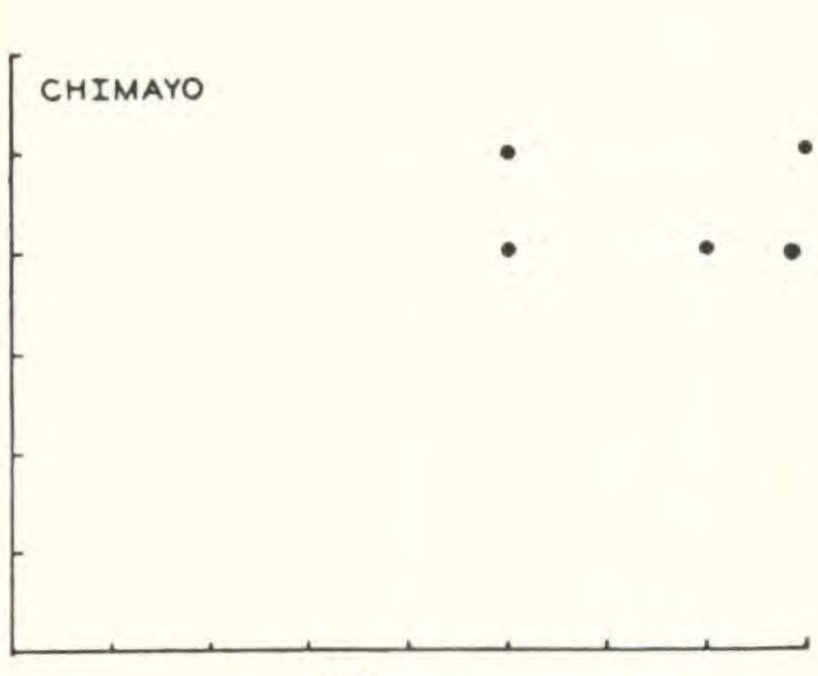

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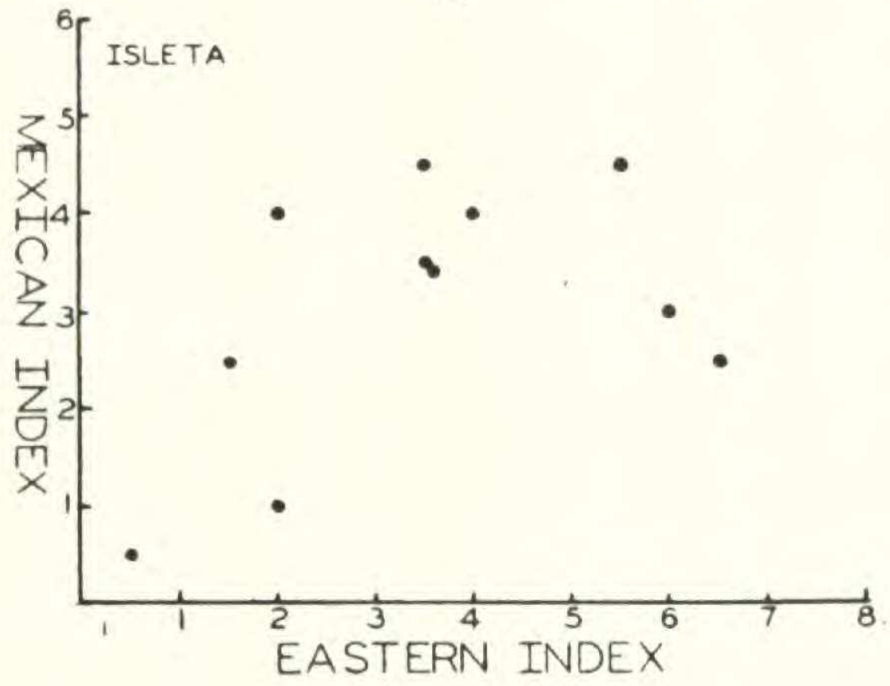

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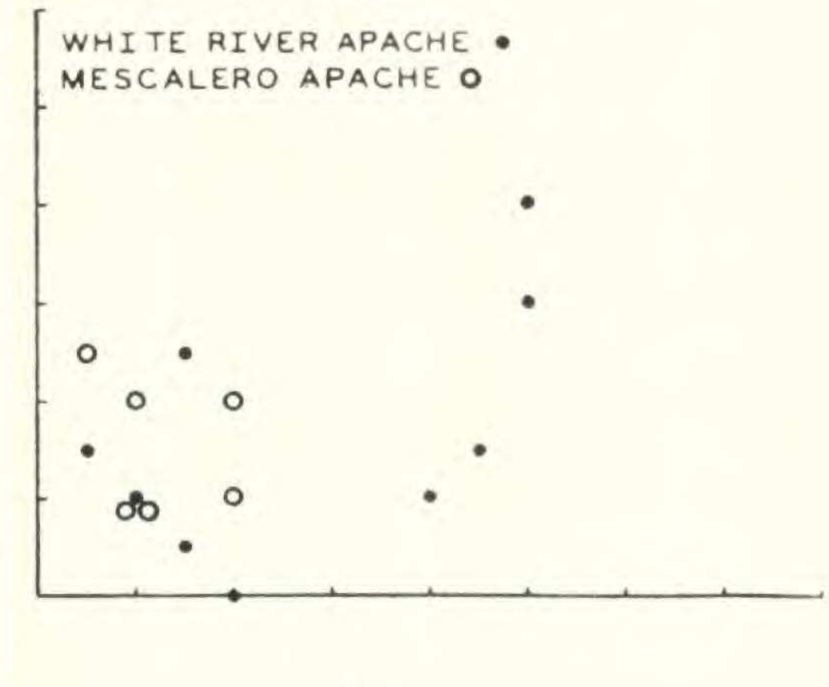

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Figs. 3–18. Scatter diagrams showing individual ears of maize measured according to a "Mexican Index" on the vertical scale and an "Eastern Index" on the horizontal scale. Further explanation in text.

Six Nations of New York state all were found to score: y, 0; x, 8. One ear of a primitive pointed dent maize from Michoacán, Mexico, scored: y, 7; x, 0. Much of the corn from the neighborhood of Mexico City scores: y, 6; x, 2. The material in our collections from the Pima, the Papago, and prehistoric Basketmaker maize scores either —2, —2 or somewhere between there and 0, 0.

The two indices plotted at right angles to each other give us, therefore, a comparison grid 9 units high and 11 units long. Its upper left-hand corner represents a sharply tapering, highly dented Mexican corn and its lower right-hand corner the big "crescent-seeded" types of eastern North America. The upper right-hand corner should denote corn in which both the Mexican and Eastern complexes are highly developed. It would therefore be a large-eared, large-shanked, wide-leaved corn, highly dented with many rows, and a markedly tapering ear which bulges at the base. Such a type of corn is fairly common in the more highly developed maize-growing regions in Mexico. In the Southwest it spread to such old Spanish-American communities as those at Santa Fe and Chimayo.

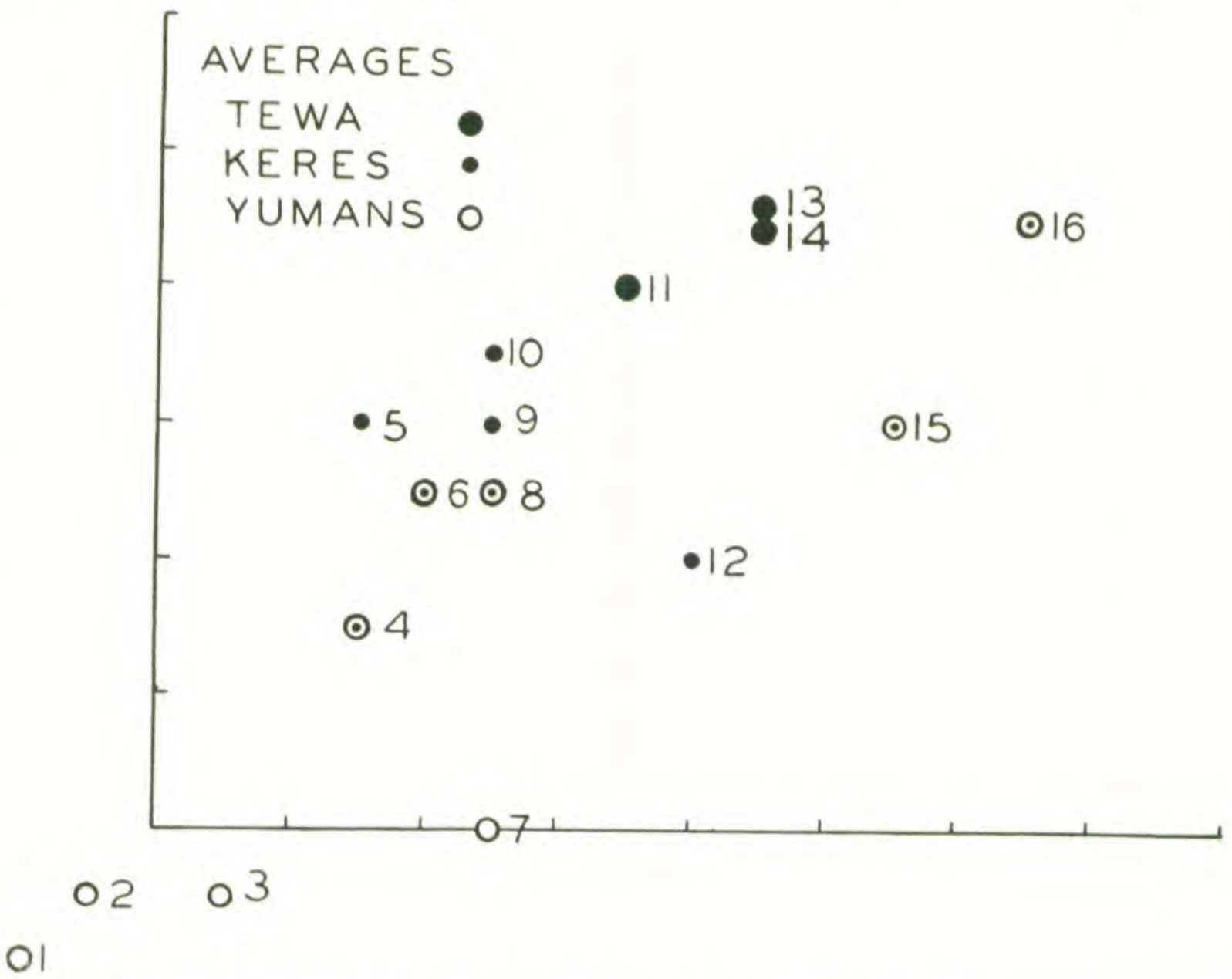


Fig. 19. Data of figs. 3–18 averaged by tribes. Language groups represented in part. Each symbol represents the average of all the measured collections from one tribe as in figs. 1 and 2. Dot-in-circle symbol is for various tribes not falling in one of the three designated language groups. 1 signifies Papago; 2, Yuma; 3, Mohave; 4, Hopi; 5, Cochiti; 6, Zuñi; 7, Havasupai; 8, Navaho; 9, Laguna; 10, San Felipe; 11, Isleta; 12, Acoma; 13, San Juan; 14, San Ildefonso; 15, Tesuque; 16, Chimayo.

We can use the grid in two ways, either to show the morphology of single ears with relation to these four extreme types or to compare the theoretical averages of particular collections. Our data from the Southwest are presented, tribe by tribe, in figs. 3–18. In fig. 19 the averages of each tribe are given for

comparison with each other. In fig. 20 the measured ears in our original collection are diagrammed, using the same grid as was used in figs. 3–18. When the entire lot is inspected in fig. 20, it is apparent that the maize of the desert-dwelling Indians is fairly well set off from that of the Pueblos. The Puebloan maize can be more or less arbitrarily divided into an intermediate type, and into Puebloan, which varies from strongly Eastern to strongly Mexican. In Table II the entire collection is presented in a tabular summary according to this classification.

When the above classification had been completed, instead of drawing dots on paper, a large table top was marked off with the appropriate squares and the actual ears were laid out on the enlarged grid. After this was done it was evident that the classification was quite a natural one (Anderson and Cutler, '42), since it put similar qualities together in addition to those which had been used in making the indices. This was particularly noticeable for color; the whites were strongest around the 0, 0 point and the red pericarp colors (P) were concentrated in the upper right-hand corner of the figure.

In short, an analysis of the color differences brings out the same points as the analysis of the shape and size differences presented above. Color is such a technically complex problem genetically that its analysis has been undertaken jointly with Dr. E. G. Anderson and the results will be published separately. The chief points brought out by this analysis are as follows: In so far as their color genes are concerned, the maize varieties of the Southwest are of two extreme types with numerous intermediates. One of these extreme types prevails among the Papago

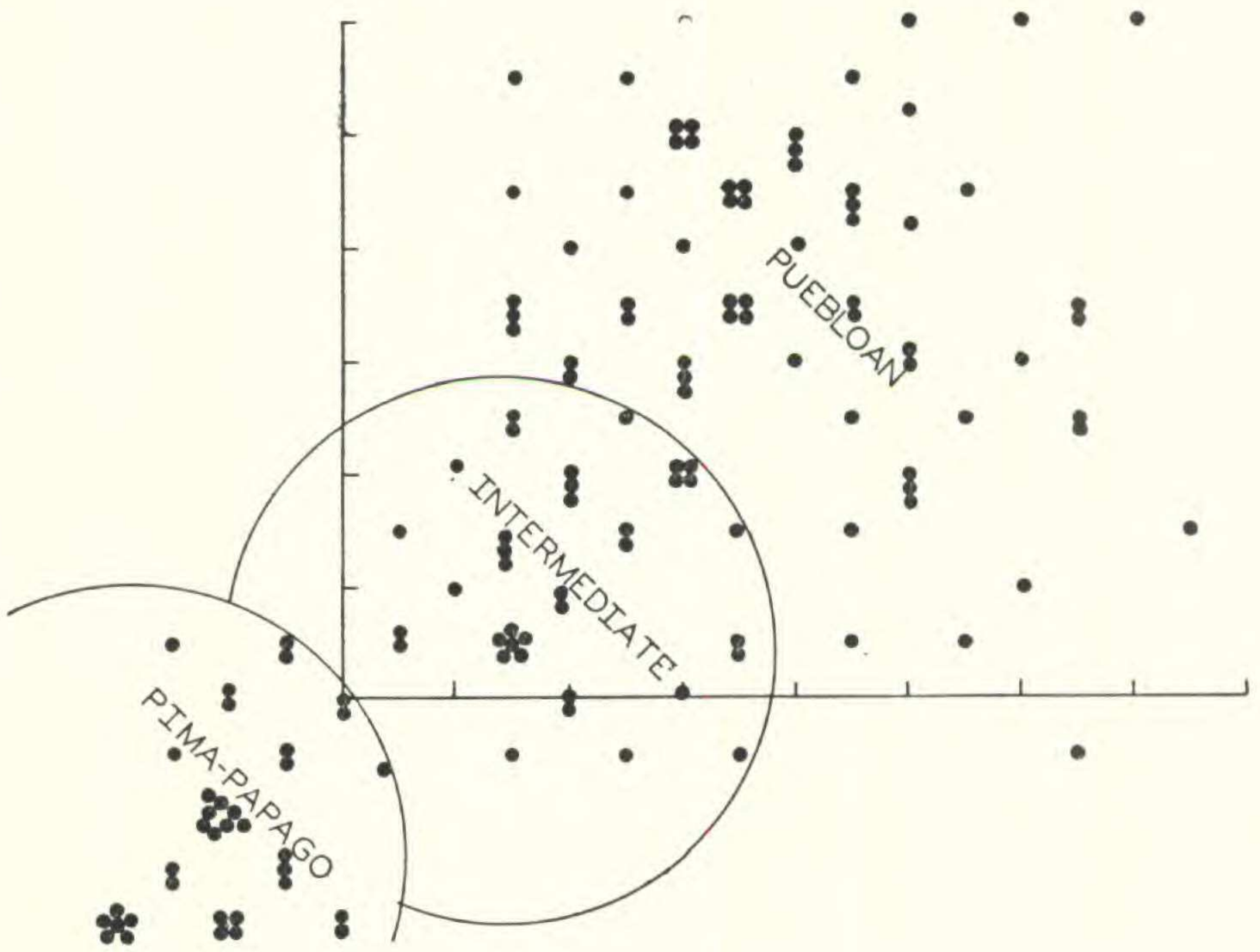


Fig. 20. Scatter diagram showing all the measured ears from the Southwest, using the same two indices as in figs. 3–19. Each dot represents a single ear.

and related tribes. It is a gene combination (ccrr) apparently common in west Mexico and in South America. It differs only slightly (though significantly) from that of Basketmaker maize. The other extreme type is characteristic of the eastern Pueblos while the maize of the western Pueblos consists of various combinations of these two extremes.

TABLE II

MEDIAN VALUES

	Number of ears measured	*Prevailing sub-race or races of maize*	*Kernel diameter in mm.*	*Number of rows*	*Mid-cob diam. in mm.*	*Shank diam. in mm.*
Desert Indians						
Papago	62	Pima-Papago	9	12	36	14
Yuma	7	Pima-Papago	8	10	32	10
Mohave	5	Pima-Papago	10	10	37	11
Hopi & Neighbors						
Havasupai	10	Pima-Papago & Intermediate	11	12	41	19
Hopi	19	Intermediate & Puebloan	9	14	38	18
Zuñi	7	Intermediate & Puebloan	9	16	40	23
Keres-speaking Pueblos						
San Felipe	7	Intermediate & Puebloan	9	16	41	24
Acoma	13	Intermediate & Puebloan	10	12	42	24
Laguna	16	Intermediate & Puebloan	9	14	43	22
Cochiti	5	Intermediate & Puebloan	9	16	44	24
Tewan Pueblos						
San Juan	5	Puebloan	9	16	45	34
Taos	6	Puebloan	9	12	42	32
Tesuque	6	Puebloan	11	12	43	34
San Ildefonso	14	Puebloan	10	14	44	32
Isleta	10	Puebloan	10	16	45	26
Nambe	3	Intermediate & Puebloan	10	14	38	30
Jemez	3	Puebloan	9	16	46	28
Intrusives						
Mescalero Apache	6	Intermediate	8	14	38	16
White River Apache	10	Intermediate & Puebloan	10	12	42	18
Navajo	26	Intermediate & Puebloan	10	14	41	22
Chimayo Sp. Amer.	4	Spanish	12	14	51	22
Santa Fe Sp. Amer.	3	Spanish	12	14	52	24

A number of facts are apparent from figs. 3 to 20:

1. The maize of the desert Indians (Yuma, Mohave, Cocopa, Pima, Papago) is comparatively uniform and essentially similar. It is not very different from the maize of the widely distributed prehistoric Basket-makers.

2. The maize of the pueblo-dwelling Indians is much more variable both as to the varieties grown by a single tribe and as to differences between tribes. In general, the maize of the eastern Pueblo people is much more Eastern-like than that of the western Pueblos.

3. Of all the Pueblos, the maize of the Hopi shows the least Eastern influence. Some of it is almost identical with Basketmaker maize. As a whole, it is rather like such corn which has been strongly influenced by the Mexican complex.

4. Zuñi maize is much like Hopi, but in our admittedly incomplete collections it lacks the Basketmaker-like varieties.

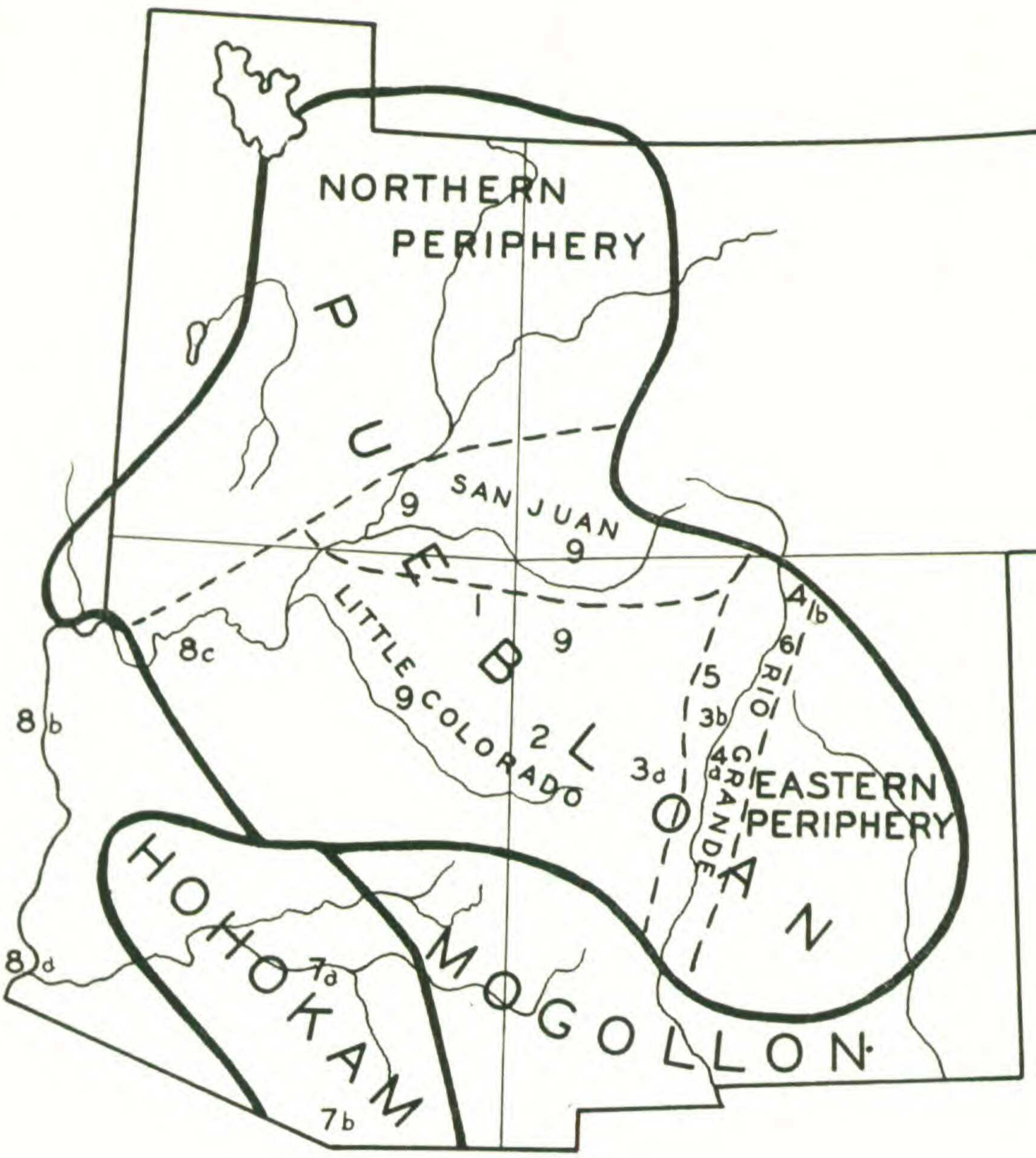
5. The Keresan Pueblos are all very similar and grow a type of maize which is roughly intermediate between the Pima-Papago and the eastern Pueblos. They might well have derived a good deal of their corn from the Hopi, an impression which is strengthened when the color is also considered.

6. The eastern Pueblos, considered as a whole, have about the same amount of Mexican complex as the Keresan, but show much more Eastern influence. As a whole, they are far from uniform and each one presents certain special features. By pueblos these are as follows:

San Ildefonso.—This pueblo shows a strong "Spanish" influence. This is not surprising since it is practically in the outskirts of the old Spanish-American town of Santa Fe. When the ears of our collections from the pueblo and from Santa Fe are laid side by side there can be little doubt that the San Ildefonso maize has been extensively mixed with that from the Spanish community near by.

Isleta.—With the exception of a few ears of maize, our collections from this pueblo are very similar to those from the western Pueblo area. This is to be expected since it is known that this pueblo took in a considerable number of Keresan-speaking refugees. Mrs. Parsons reports that clan structure shows resemblances to both Keresan and Tewa. Considering its location and its history it is therefore to be expected that the Isleta maize should include both types.

San Juan.—This maize is all very much alike and all similar to that from Mexican villages. This, too, is what might have been expected. The site of the first Spanish settlement in the Southwest, San Gabriel de los Españoles, is just across the river. The mission was succeeded by a little Mexican town, "Chamita", which was unfortunately on the right-of-



KEY TO MAP OF THE SOUTHWEST

ARCHAEOLOGIC AREAS

Puebloan area:
San Juan—the early center of development.
Little Colorado—area of early expansion.
Northern Periphery—an area briefly occupied after 1000.
Rio Grande—area of late settlement; present sites of most pueblos on river bottoms with irrigated fields a post-Spanish innovation.
Eastern Periphery—late eastward expansion, abandoned in post-contact times.
Hohokam area: A major culture province of differing origin from the Puebloan.
Mogollon area: A major culture province of controversial origin; suspected of being Eastern in its derivation.

KEY TO TRIBAL AND LINGUISTIC GROUPINGS

Language group	*Pueblos or tribes*
1. Shoshonean	Hopi (First Mesa: Sichomovi, Walpi, also the Tewa village of Hano since about 1700; Second Mesa: Mishongnovi, Shumopovi; Third Mesa: Oraibi, Hotevilla, Baeabi)
2. Zuñian	Zuñi
3. Keresan	a. Laguna, Acoma b. Cochito, Santo Domingo, San Felipe, Zia, Santa Ana
4. Tiwa	a. Isleta, Sandia b. Taos, Picuris
5. Jemez	Jemez, Pecos, (Pecos joined Jemez, 1838)
6. Tewa	Nambe, Tesuque, San Ildefonso, San Juan, Santa Clara
7. Piman	Pima, Papago
8. Yuman	a. Yuma b. Mohave c. Havasupai
9. Athapaskan	Navaho, Apache

Notes.—Shoshonean was widely spread in the Great Basin, but only the Hopi took on Puebloan culture. Zuñian is of unknown relationship. The Tiwa, Jemez, Tewa, Keresan all belong in the Tanoan speech family, which is suspected to be of Eastern origin. The Piman are a northwest Mexican group. The Yuman seems to be an old group in the area. The Athapaskans are the latest entries into the area, probably beginning to drift in after 1000 A.D., and settling in between the Pueblos.

way of the railroad when it came through. The Mexicans accordingly moved across the river to join the pueblo of San Juan, which must have been in a depleted condition to have accepted recruits from outside the pueblo.

Taos.—While a larger collection from this interesting pueblo would be highly desirable, even our small collection seems to be significant. It includes some typical Pueblo types and two ears which are almost purely Eastern. This accords with the general Eastern cultural affinities of the Taos pueblo.

Tesuque.—While none of the ears from the pueblo are as purely Eastern as some of those from Taos, the general average is more Eastern than is that of any other pueblo. Tesuque is generally thought to be a Pueblo "shell" which was taken over by a non-Puebloan people. Judging from the maize alone, these newcomers might have been related to (or in close contact with) tribes of the Great Plains.

The significance of these conclusions must be placed against a background of southwestern culture history. There are in the Southwest two well-known basic cultures, the Anasazi and the Hohokam. There may well be a third, the Mogollon culture. The first two are the best known and our agricultural material relates to them. The Mogollon culture will, therefore, be reluctantly omitted from this discussion.

The two basic cultures with which we are concerned are the Anasazi and the Hohokam (see Map). Anasazi is a term used to refer to the culture which developed in the plateau region of the Southwest. The evidence to date shows that the Basketmakers, a non-agricultural people who had been living by hunting and gathering, learned of agriculture and began about 300 A.D. (or possibly earlier) to grow corn and squash *(Cucurbita moschata)*. These agricultural beginnings are usually placed in the "Four Corners" region (adjacent corners of Arizona, Utah, Colorado, and New Mexico). The crops and the idea of farming are clearly derived from some outside source.

Farming was apparently of minor importance in this early period. Crops may well have been handled as they were by some of the early historic Apache; i.e., corn and squash were planted and left to survive as best they could while the tribe went off hunting and gathering.

At a later period (500–700 A.D., Basketmaker 3) the Basketmakers show evidence of further contacts with some outside culture, and further cultural changes occurred. Pit houses were built (no houses are known from the earlier periods), pottery making began, and more varieties of corn appeared.

Around 700 A.D. more cultural changes occurred and sufficient new traits were introduced that a new cultural designation, Puebloan, is given. The first Pueblo period (700–900 A.D.) centered in the old Basketmaker area. Cultural developments, e.g., house types and pottery types, continued and further intro-

ductions of corn types are probable.

In each of these preceding periods there was some expansion outward from the central area in the "Four Corners" region. This expansion reached its maximum between 900–1100, Pueblo 2. People related to the Pueblo (Anasazi) culture then extended from southeast of Flagstaff, Arizona, nearly to Salt Lake, and in the latitude of the Grand Canyon reached from the Rio Grande to the Colorado. There was considerable regional variation. Large, many-roomed pueblos were already being built in the Chaco Canyon, the people of Mesa Verde were living in small masonry houses, while pit houses remained in use near Flagstaff. In all areas, however, the people were fully sedentary agriculturalists.

From the very beginning these people had been occupying a distinctly arid country and raising crops by dry farming. They must, therefore, have started with highly specialized crops. By locating their fields advantageously in reference to soil, run-off, and higher elevations with their greater precipitation they succeeded for hundreds of years in raising crops in areas considered impossible for modern agriculture.

In Pueblo 3 (1100–1300) a shrinking of the occupied area became apparent, and the settlements of small villages of loosely grouped houses now became compact towns of considerable size which were often built in defense locations. Houses were built wall to wall, several stories high, and entrance to first-floor rooms was normally from the roofs and not from the exterior ground level.

The attempted explanations for these happenings are still unreconciled. They fall into three categories. One theory points to climatic changes; another points primarily to the effects of invasion of nomadic peoples; a third to soil exhaustion and erosion. A variant of the second calls attention to the effect of warfare between the various Pueblo peoples.

That the distribution of corn types fits both the linguistic grouping and geographic position has already been pointed out. This may either imply that the various linguistic groups brought varying races of corn or that their geographic position in the Southwest gave them greater or lesser opportunities to get new varieties of corn. In view of the conservatism of the people, the high degree of adaptation of some of the earliest corn types, and the sudden appearance of new races of corn in special areas (e.g., dent corn of extreme Mexican type in the Northern Periphery), it seems fairly possible that the various linguistic groups represent different immigrations of people, each of which brought new agricultural material. The time of these introductions is not yet established, but further research now under way may do much to clarify this.

Perhaps a movement of peoples is implied in the first appearance of corn in the Four Corners region. Clearly, there were further introductions of corn types, between Basketmaker and Pueblo times. Whether other introductions occurred in the 600 years between Pueblo 1 and the "great drought" of 1300, or whether the next importation of corn came with peoples unsettled at the time of the "great drought" is not yet clear. It is even quite

possible that some of the corn types limited to the upper Rio Grande pueblos are post-Spanish, for after the Pueblo revolt some of the people are known to have fled into the Plains. It is not unlikely that some of these people later returned to the Rio Grande bringing new maize varieties with them, e.g., to Tesuque.

It is clear from the above that the development in the Anasazi area was a very complex affair involving different peoples and cultures. The cultural evidence suggests that in the thousand years after the introduction of agriculture there were repeated movements of people into the area. The implication of multiple introductions is particularly strong in the languages represented.

We are quite clear on the fact of multiple introductions of corn into the Pueblo area. We are sure of separate corn varieties appearing in Basketmaker 2 and again in the Basketmaker 3-Pueblo 1 periods; thereafter we can not yet place the time of arrival of the various races of corn that are modernly represented in the Anasazi area. Further work will surely make this possible.

The other basic culture of the Southwest to be considered here is the Hohokam. It is both less well known and less complex. Our knowledge concerning it begins about 600 A.D. according to Gladwin ('42, p. 4). At this time it seems already to have been a developed culture with agriculture and pottery, hence its true beginnings must go back of that date. The people lived in loose villages and occupied the middle Gila and the Salt River valleys, areas utilizable in their lower parts only by irrigation, whether from arroyo flooding or by using the waters of major streams. True canal irrigation was developed very early. Although we know less of this culture than we do of the Anasazi sequence, the evidence to date shows no such complexity in development as is found on the plateau. Culture periods are discernible but in the main they seem the result of local development with little outside influence until very late in their history.

The great problem of the Hohokam centers on their survival. After the mid-14th century the record becomes very incomplete. When the Spanish arrived they found the Hohokam area occupied by the Pima-Papago peoples. These latter were, and remain, village-dwelling farmers retaining the old Hohokam crops and some irrigation. The agricultural evidence suggests that they may be (at least in part) the descendants of the Hohokam.

A great contrast runs throughout these two cultures. The Anasazi developed into town-dwelling peoples with a tradition of masonry houses; they specialized in dry farming, developed elaborate rituals for rain, and had distinctive pottery techniques, etc. Their culture was complex, perhaps partially because of the different elements entering into its make-up. The Hohokam remained village dwellers with little evidence of alien peoples or cultures influencing them. They very early developed irrigation and established an elaborate ditch system in the Gila and Salt valleys. In religion, art forms, specific crops, and many more details they differed markedly from the Pueblo peoples.

This contrast is clearly reflected in the corn of the Southwest. Pueblo corn is complex in its make-up. It changes from period to period and to-day varies

throughout the Pueblo area. By comparison with the maize of other native areas, Hohokam maize is extremely uniform, probably one of the most uniform races one will ever find under primitive cultivation. It seems to have changed little in the past thousand years.

One of the crucial points in the relation of the Anasazi and the Hohokam revolves around the relationship between Basketmaker corn and Hohokam corn. We know Basketmaker corn from its preservation in the dry caves of the Southwest. It is closer to the Hopi and the Pima-Papago corn of to-day than it is to the maize of the Rio Grande pueblos. Some of the strains of Hopi corn fairly represent late Basketmaker corn. Hohokam corn is known from the published reports of the Snake Town plant materials (Castetter and Bell, '42), and from Haury's excavations in Ventana Cave (paper in press, 1944, but we have examined the maize remains). It is close to, though not identical with, the corn grown to-day by the Pima and Papago Indians. We have therefore a distinct race of corn in the Southwest that is common to the two different cultural areas at the earliest levels and which survives in part among the westernmost of the Puebloan peoples and among the desert-dwelling peoples who are presumably the descendants of the Hohokam.

We have not yet photographed and measured all the prehistoric North American corn available in museums and private collections. Until that job has been done an extended discussion is premature. However, from the prehistoric maize we have already seen and the junior author's studies of modern Mexican maize, it seems probable that there were at least three waves of prehistoric maize in North America. The first was a small-cobbed, small-seeded, tesselated, compressed, undented race. It survives to-day in its purest form in the maize of the Pima and Papago. It can be seen only slightly mixed in the early varieties of the Pawnee and other Missouri River Indians, in old varieties from the Gaspé Peninsula in Canada, and in *Maiz reventador* and related varieties from western Mexico. Its presence in Oaxaca, Mexico, in 400 to 600 A.D., is suggested by the representations of maize on the funerary urns of the Zapotecs, which resemble Basketmaker maize more closely than they do the modern varieties of Oaxaca. It is one of the types recovered from mounds and other archaeological sites in the Mississippi Valley (where it is apparently one of the earlier types to appear, though the evidence is not consistent on this point). The other two waves we have already described as "Mexican" and "Eastern." In later papers we hope to be able to work out the order of their appearance and perhaps ultimately to trace them back to their origins.

SUMMARY

1. The technical advantages of *Zea Mays* for cytological, genetical, and archaeological study are described. It is concluded that when we eventually combine the information from these three disciplines we shall have a more complete picture of maize in space and in time than will ever be possible for any other

world crop.

2. Because of its geographic and climatic isolation, southwestern maize is simple in its variation pattern as compared with that of Mexico or Guatemala.

3. The importance of collecting samples from remote and relatively conservative Indian communities is discussed.

4. One of the most significant maize characters in the Southwest is the denting of the kernel due to a cap of soft starch. Its genetics is obscure but a large number of genes are involved. Much of the denting of Indian varieties in this area is of such slight grade that it might readily be overlooked. Breeding experiments have proved that even the slight grades of it in that area are genetically controlled and are not merely due to harvesting when immature.

5. Maize in the Southwest has come from at least four different sources: the Basketmakers, the Hohokam, the Mexican plateau, and eastern North America. The maize of the Basketmakers and of the Hohokam was very similar but apparently distinct.

6. In the Southwest the following three characters of the maize ear are correlated: ear taper, row number, and denting of the kernel. They are referred to as the Mexican complex of characters. Kernel width, shank diameter, an enlarged butt to the ear, and straight rows are also correlated. They are called the "Eastern" complex.

These eight characters and two others were used in constructing two indices for measuring southwestern corn. Plotted on x and y axes they form a "comparison grid" on which scatter diagrams of the maize from one pueblo may be compared with the maize from another, or on which the average values of different collections may be similarly compared.

7. Scatter diagrams are presented for a portion of our collections of modern maize and a summary of the conclusions drawn from them is given on pages 309-312.

8. An attempt is made to interpret these findings in terms of what is known about the history of the Southwest from the beginnings of agriculture to the present. The following hypotheses seem fairly well established:

A. The Basketmakers and Hohokam brought similar, though non-identical, strains of maize into the area. The Hohokam maize apparently was brought up the west coast of Mexico and has remained with only slight modifications as that now grown by the Pima and Papago.

B. The maize of the early Basketmakers was progressively modified more and more in the direction of the maize of the Mexican plateau, causing an increase in row number and in the amount of denting of the kernel.

C. The maize of the Southwest was greatly modified from 1200 to 1300 A.D. The complex of characters introduced at that time is characteristic of the eastern United States and the easternmost pueblos were most affected and the westernmost the least.

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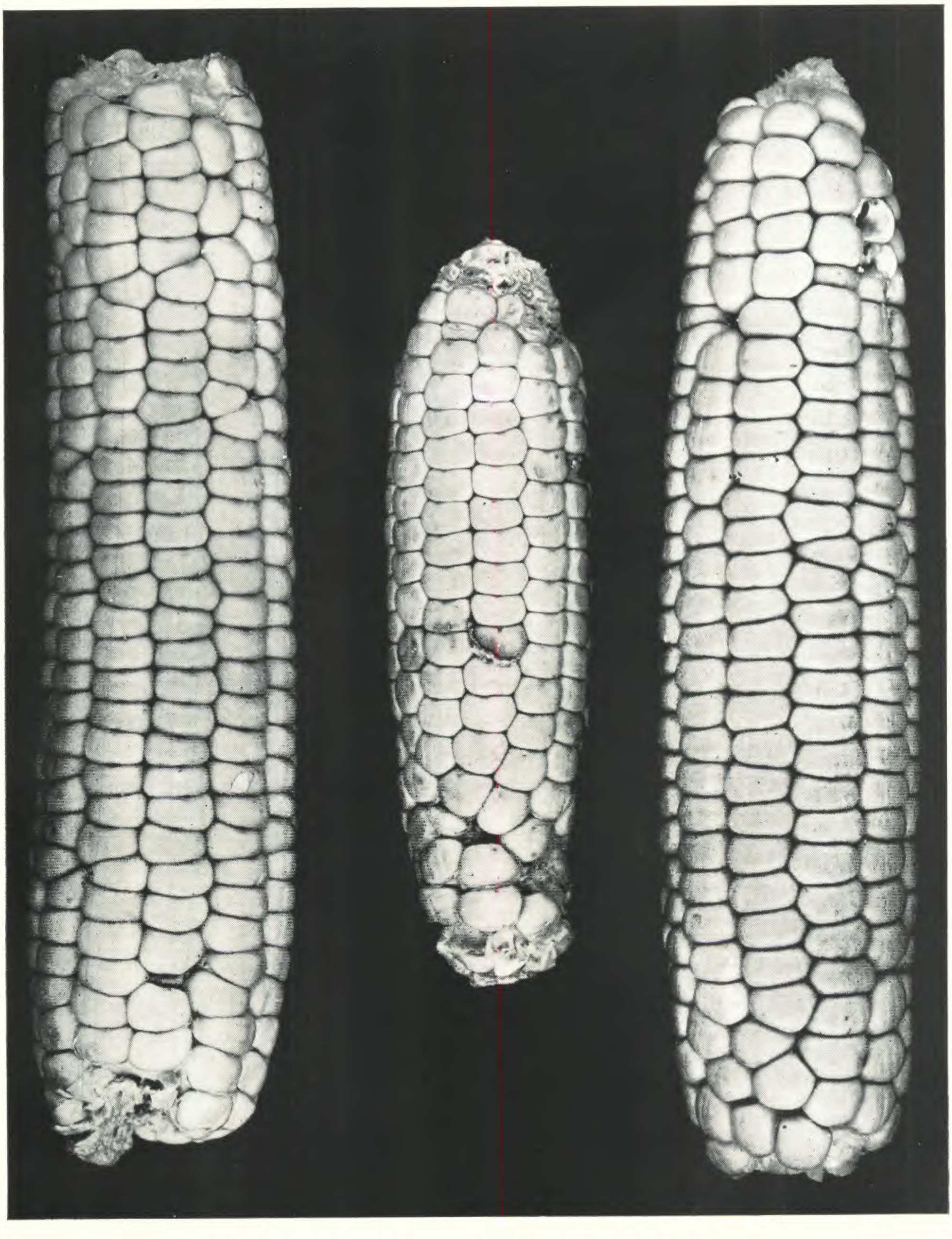
Explanation of Plates

Plates 2–4 are from the special collection of maize photographs assembled in the Museum of Anthropology of the University of California at Berkeley. We are indebted to E. W. Gifford for permission to reproduce them. All three illustrations were photographed, printed, and reproduced at approximately natural size.

PLATE 2

Papago white flour corn. Three ears purchased from Mrs. Margaret Harvey (Xavier) at Choulick, near Sells, Arizona, on the Papago reservation, by Edgar Anderson and Emil Haury. In the Anderson sollection they are Choulick Nos. 1–3, from left to right in serial order. Their scores on the two indices used in this paper are as follows (in each case the Eastern Index is given first, followed by the Mexican Index): —2, —1; —2, —2; —2, —2.

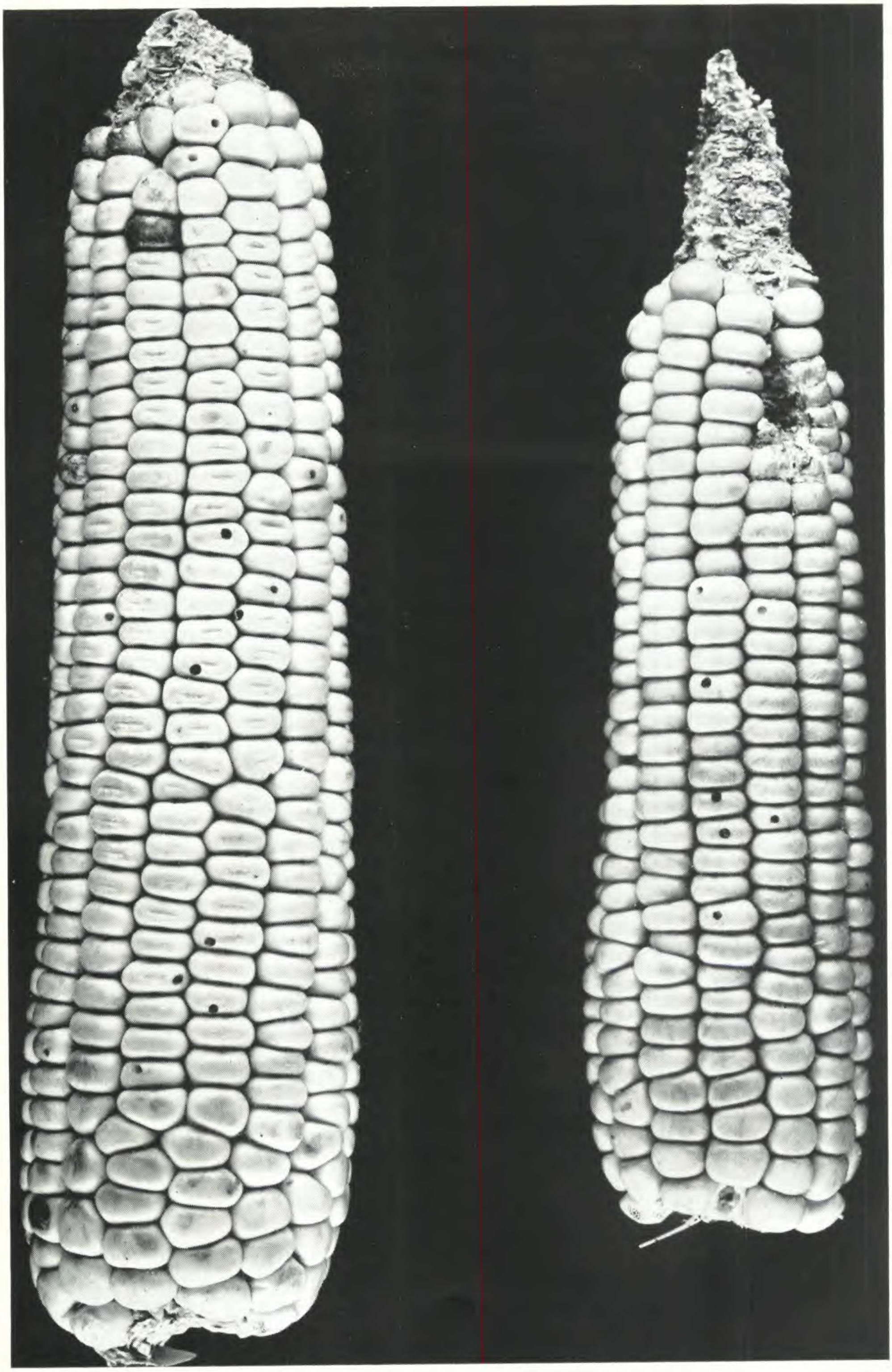


CARTER & ANDERSON—MAIZE IN THE SOUTHWEST

EXPLANATION OF PLATE

PLATE 3

Hopi white flour corn. Right, Carter No. 497, left, Carter No. 498. The former scores 1/2 on the Eastern Index and 1-2 on the Mexican Index. The latter scores 2, 3. Note the faint crease or "dent" at the apex of some of the kernels. This degree of denting is commonly found in Hopi flour corn.



CARTER & ANDERSON—MAIZE IN THE SOUTHWEST

EXPLANATION OF PLATE

PLATE 4

Right, Isleta red corn. Carter No. 315, scoring 6½ on the Eastern Index and 2½ on the Mexican. Note the wide seeds and the straight rows of uniform kernels.

Left, Tesuque red-and-white corn (mosaic pericarp). Carter, scoring 4 on the Eastern Index and 5 on the Mexican. At the base of the photograph note the heavy, well-developed shanks which support the ears. These are characteristic of much modern Pueblo corn but did not appear in most of the Southwest until after 1200 A.D.